PB88-150958

Guideline on Air Quality Models (Revised). Supplement A

(U.S.) Environmental Protection Agency
Research Triangle Park, NC

Jul 87

U.S. Department of Commerce
National Technical Information Service
NTIS

PB88-150958

EPA-450/2-78-027R
SUPPLEMENT A
JULY 1987

SUPPLEMENT A

TO THE

GUIDELINE

ON

AIR QUALITY MODELS (REVISED)

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office Of Air And Radiation
Office Of Air Quality Planning And Standards
Research Triangle Park, North Carolina 27711

REPRODUCED BY
U.S. DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL
INFORMATION SERVICE
SPRINGFIELD, VA 22161

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA-450/2-78-027R,Suppl.A		PB88 150958/AS

4. TITLE AND SUBTITLE	5. REPORT DATE
Supplement A to the Guideline on Air Quality Models (Revised)	July 1987
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Source Receptor Analysis Branch Office of Air Quality Planning and Standards U.S. Environmental Protection Agency Research Triangle Park, NC 27711	10. PROGRAM ELEMENT NO.
	11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
	14. SPONSORING AGENCY CODE EPA 200/04

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The guideline recommends air quality modeling techniques that may be applied to air pollution control strategy evaluations and new source reviews, including prevention of significant deterioration. It is intended for use by EPA Regional Offices in judging the adequacy of modeling analyses performed by EPA, by State and local agencies, and by industry and its consultants. It also identifies modeling techniques and data bases that EPA considers acceptable. The guideline makes specific recommendations concerning air quality models, data bases, and general requirements for concentration estimates.

This is Supplement A to the guideline. It contains: (1) addition of a specific version of the Rough Terrain Diffusion Model (RTDM) as a screening model, (2) modification of the downwash algorithm in the Industrial Source Complex (ISC) model, (3) addition of the Offshore and Coastal Dispersion (OCD) model to Appendix A, and (4) addition of the AVACTA II model to Appendix B.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution Atmospheric Models Atmospheric Diffusion Meteorology	Diffusion Modeling Gaussian Plume Models Clean Air Act	

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Unlimited	None	25
	20. SECURITY CLASS *(This page)*	22. PRICE
	None	

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

Instructions for Inserting Supplement A into the Guideline on Air Quality Models (Revised)

Item	Take Out	Add In
Table of Contents List of Tables	p. ix	p. ix
Chapter 5	pp. 5-4 thru 5-5	pp. 5-4 thru 5-6
	p. 5-6	p. 5-8
	-	pp. 5-9 and 5-10
Chapter 7	p. 7-9	p. 7-9
Chapter 12	p. 12-9	p. 12-9
Appendix A:		
Table of Contents	first page	p. A-i
RAM Model*	pp. A-15 and A-16	pp. A-15 and A-16
ISC Model	pp. A-21 thru A-24	pp. A-21 thru A-24a
OCD Model	-	pp. A-39 thru A-42
References	pp. AR-1 and AR-2	pp. AR-1 and AR-2
Appendix B:		
Table of Contents	first two pages	pp. B-i and B-ii
AVACTA II Model	-	pp. B-111 thru B-114
References	pp. BR-3 and BR-4	pp. BR-3 and BR-4

* Contains reference to the updated user's guide.

ATTENTION REPRO: _____

When printing this document it should be
3 hole punch.

DO NOT PHOTOGRAPH THIS PAGE

CASE FILE

LIST OF TABLES

Table No.	Title	Page
4-1	Preferred Models for Selected Applications in Simple Terrain	4-4
5-1	Preferred Options for the SHORTZ/LONGZ Computer Codes When Used in a Screening Mode	5-8
5-2	Preferred Options for the RTDM Computer Code When Used in a Screening Mode	5-9
9-1	Model Emission Input Data for Point Sources	9-5
9-2	Averaging Times for Site-Specific Wind and Turbulence Measurements	9-20
9-3	Wind Fluctuation Criteria for Estimating Pasquill Stability Categories	9-21
9-4	Nighttime P-G Stability Categories Based on σ_A from Table 9-3	9-22

5.2.1 Screening Techniques

In the absence of an approved case-specific, refined, complex terrain model, four screening techniques are currently available to aid in the evaluation of concentrations due to plume impaction during stable conditions: the Valley Screening Technique as outlined in the Valley Model's User's Guide,[19,25] COMPLEX I,[19] SHORTZ/LONGZ,[26] and the Rough Terrain Dispersion Model (RTDM)[91] in its prescribed mode described below. These methods should be used only to calculate concentrations at receptors whose elevations are greater than or equal to plume height. Receptors below stack height should be modeled using a preferred simple terrain model (see Chapter 4). Receptors between stack height and plume height should be modeled with both complex terrain and simple terrain models and the highest concentration used. (For the simple terrain models, terrain may have to be "chopped-off" at stack height, since these models are frequently limited to receptors no greater than stack height.)

If a violation of any NAAQS or the controlling increment is indicated by using the Valley Screening Technique, a second- or third-level screening technique may be used. A site-specific data base of at least one full year of meteorological data is preferred for use with either the second- or third-level screening technique. If more data are available, they should be used. Meteorological data used in the analysis should be reviewed for both spatial and temporal representativeness.

Placement of receptors requires very careful attention when modeling in complex terrain. Often the highest concentrations are predicted to occur under very stable conditions, when the plume is near, or impinges on, the terrain. The plume under such conditions may be quite narrow in the vertical, so that a change in a receptor to a location where the terrain is as little as 25 meters or so higher or lower may make a substantial change in the predicted concentration. Receptors within about a kilometer of the source may be even more sensitive to location. Thus, a very dense array of receptors may be required in some cases. In order to avoid excessively large computer runs due to such a large array of receptors, it is often desirable to model the area twice. The first model run would use a moderate number of receptors carefully located over the area of interest. The second model run would use a more dense array of receptors in areas showing potential for high concentrations, as indicated by the results of the first model run.

5.2.1.1 Initial Screening Technique

The initial screen to determine 24-hour averages is the Valley Screening Technique. This technique uses the Valley Model with the following worst-case assumptions for rural areas: (1) P-G stability "F"; (2) wind speed of 2.5 m/s; and (3) 6 hours of occurrence. For urban areas the stability should be changed to "P-G stability E."

When using the Valley Screening Technique to obtain 24-hour average concentrations the following apply: (1) multiple sources should be treated individually and the concentrations for each wind direction

summed; (2) only one wind direction should be used (see User's Guide,[25] page 2-15) even if individual runs are made for each source; (3) for buoyant sources, the BID option may be used, and the option to use the 2.6 stable plume rise factor should be selected; (4) if plume impaction is likely on any elevated terrain closer to the source than the distance from the source to the final plume rise, then the transitional (or gradual) plume rise option for stable conditions should be selected.

The standard polar receptor grid found in the Valley Model User's Guide may not be sufficiently dense for all analyses if only one geographical scale factor is used. The user should choose an additional set of receptors at appropriate downwind distances whose elevations are equal to plume height minus 10 meters. Alternatively, the user may exercise the "VALLEY equivalent" option in COMPLEX I and note the comments above on the placement of receptors in complex terrain models.

5.2.1.2 Second-Level Screening Technique (Rural)

If the area is rural, the suggested second-level screening technique is COMPLEX I for all averaging times. COMPLEX I is a modification of the MPTER model that incorporates the plume impaction algorithm of the Valley Model. It is a multiple-source screening technique that accepts hourly meteorological data as input. The output is the same as the normal MPTER output. When using COMPLEX I the following options should be selected: (1) set terrain adjustment IOPT(1) = 1; (2) set buoyancy induced dispersion IOPT (4) = 1; (3) set IOPT (25) = 1; (4) set the terrain adjustment values to 0.5, 0.5, 0.5 0.5, 0.0, 0.0, (respectively for 6 stability classes); and (5) set Z MIN = 10.

Gradual plume rise should be used to estimate concentrations at nearby elevated receptors, if plume impaction is likely on any elevated terrain closer to the source than the distance from the source to the final plume rise (see Section 8.2.5).

5.2.1.3 Second-Level Screening Technique (Urban)

If the source is located in an urbanized (Section 8.2.8) complex terrain valley, then the suggested second-level screening technique is SHORTZ for short term averages or LONGZ for long term averages. (SHORTZ and LONGZ may be used as screening techniques in these complex terrain applications without demonstration and evaluation. Application of these models in other than urbanized valley situations will require the same evaluation and demonstration procedures as are required for all Appendix B models.)

Both SHORTZ and LONGZ have a number of options. When using these models as screening techniques for urbanized valley applications, the options listed in Table 5-1 should be selected.

5.2.1.4 Third Level Screening Technique (Rural)

If a violation of any NAAQS or the controlling increment is indicated by using the second-level screening technique, a third-level screening technique may be used for rural applications. RTDM with the options specified in Table 5-2 may be used as a screening technique in rural complex terrain situations without demonstration and evaluation.

The RTDM* screening technique can provide a more refined concentration estimate if on-site wind speed and direction characteristic of plume dilution and transport are used as input to the model. In complex terrain, these winds can seldom be estimated accurately from the standard surface (10m level) measurements. Therefore, in order to increase confidence in model estimates, EPA recommends that wind data input to RTDM should be based on fixed measurements at stack top height. For stacks greater than 100m, the measurement height may be limited to 100m in height relative to stack base. However, for very tall stacks see guidance in Section 9.3.3.2. This recommendation is broadened to include wind data representative of plume transport height where such data are derived from measurements taken with remote sensing devices such as SODAR. The data from both fixed and remote measurements should meet quality assurance and recovery rate requirements. The user should also be aware that RTDM in the screening mode accepts the input of measured wind speeds at only one height. The default values for the wind speed profile exponents shown in Table 5-2 are used in the model to determine the wind speed at other heights. RTDM uses wind speed at stack top to calculate the plume rise and the critical dividing streamline height, and the wind speed at plume transport level to calculate dilution. RTDM treats wind direction as constant with height.

RTDM makes use of the "critical dividing streamline" concept and thus treats plume interactions with terrain quite differently from other models such as SHORTZ and COMPLEX I. The plume height relative to the critical dividing streamline determines whether the plume impacts the terrain, or is lifted up and over the terrain. The receptor spacing to identify maximum impact concentrations is quite critical depending on the location of the plume in the vertical. It is suggested that an analysis of the expected plume height relative to the height of the critical dividing streamline be performed for differing meteorological conditions in order to help develop an appropriate array of receptors. Then it is advisable to model the area twice according to the suggestions in Section 5.2.1.

5.2.1.5 Restrictions

For screening analyses using the Valley Screening Technique, Complex I or RTDM, a sector greater than 22-1/2° should not be allowed. Full ground reflection should always be used in the VALLEY Screening Technique and COMPLEX I.

---

* The RTDM model is available as part of Change 3 to UNAMAP Version 6.

Table 5-1

Preferred Options for the SHORTZ/LONGZ Computer Codes When Used in a Screening Mode

Option	Selection
I Switch 9	If using NWS data, set = 0 If using site-specific data, check with the Regional Office
I Switch 17	Set = 1 (urban option)
GAMMA 1	Use default values (0.6 entrainment coefficient)
GAMMA 2	Always default to stable
XRY	Set = 0 (50 m rectilinear expansion distance)
NS, VS, FRQ (SHORTZ) NUS, VS, FRQ (LONGZ) } (particle size, etc.)	Do not use (Applicable only in flat terrain)
ALPHA	Select 0.9
SIGEPU SIGAPU } (dispersion parameters)	Use Cramer curves (default) If site-specific turbulence data are available, see the Regional Office for advice.
P (wind profile)	Select default values given in Table 2-2 of User's Instructions If site-specific data are available, see the Regional Office for advice.

TABLE 5-2

Preferred Options for the RTDM Computer Code When Used in a Screening Mode

Parameter	Variable	Value	Remarks
PR001-003	SCALE		Scale factors assuming horizontal distance is in kilometers, vertical distance is in feet, and wind speed is in meters per second
PR004	ZWIND1	Wind Measurement Height	See Section 5.2.1.4
	ZWIND2	Not used	Height of second anemometer
	IDILUT	1	Dilution wind speed scaled to plume height
	ZA	0 (default)	Anemometer-terrain height above stack base
PR005	EXPON	.09, .11, .12, .14, .2, .3 (default)	Wind profile exponents
PR006	ICOEF	3 (default)	Briggs Rural/ASME (1979) dispersion parameters
PR009	IPPP	0 (default)	Partial plume penetration, not used
PR010	IBUOY	1 (default)	Buoyancy-enhanced dispersion is used
	ALPHA	3.162 (default)	Buoyancy-enhanced dispersion coefficient
PR011	IDMX	1 (default)	Unlimited mixing height for stable conditions
PR012	ITRANS	1 (default)	Transitional plume rise is used
PR013	TERCOR	6*0.5 (default)	Plume path correction factors
PR014	RVPTG	0.02, 0.035 (default)	Vertical potential temperature gradient values for stabilities E and F
PR015	ITIPD	1	Stack-tip downwash is used
PR020	ISHEAR	0 (default)	Wind shear, not used
PR022	IREFL	1 (default)	Partial surface reflection is used

TABLE 5-2 (continued)

Preferred Options for the RTDM Computer Code When Used in a Screening Mode

Parameter	Variable	Value	Remarks
PR023	IHORIZ SECTOR	2 (default) 6*22.5 (default)	Sector averaging Using 22.5° sectors
PR016 to 019; 021; and 024	IY, IZ, IRVPTG, IHVPTG;IEPS; IEMIS	0	Hourly values of turbulence, vertical potential temperature gradient, wind speed profile exponents, and stack emissions are not used

7.2.7 Modeling Guidance for Other Governmental Programs

When using the models recommended or discussed in this guideline in support of programmatic requirements not specifically covered by EPA regulations, the model user should consult the appropriate Federal or State agency to ensure the proper application and use of that model. For modeling associated with PSD permit applications that involve a Class I area, the appropriate Federal Land Manager should be consulted on all modeling questions.

The Offshore and Coastal Dispersion (OCD) model[92] was developed by the Minerals Management Service and is recommended for estimating air quality impact from offshore sources on onshore flat terrain areas. The OCD model is not recommended for use in air quality impact assessments for onshore sources.

88. Environmental Protection Agency, 1977. Guidelines for Interpretation of Air Quality Standards (Revised). OAQPS No. 1.2-008. U. S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS No. PB 81-196420).

89. Environmental Protection Agency, 1982. Emissions Trading Policy Statement; General Principles for Creation, Banking, and Use of Emission Reduction Credits. Federal Register, 47(67):15076-15086.

90. Meyer, S., 1983. Memorandum of February 17 to Regional Office Air Management Division Directors, Emissions Trading Policy Technical Clarifications. Office of Air, Noise and Radiation, U. S. Environmental Protection Agency, Washington, DC. (Docket Reference No. II-B-34).

91. Environmental Research and Technology, 1987. User's Guide to the Rough Terrain Diffusion Model (RTDM), Rev. 3.20. ERT Document No. P-D535-585. Environmental Research and Technology, Inc., Concord, MA. (Docket Reference No. IV-D-5).

92. Hanna, S. R., L. L. Schulman, R. J. Paine and J. E. Pleim, 1984. The Offshore and Coastal Dispersion (OCD) Model User's Guide, Revised. OCS Study, MMS 84-0069. Environmental Research and Technology, Inc., Concord, MA. (NTIS PB 86-159803).

APPENDIX A

Table of Contents

A.0 INTRODUCTION..... A-1

A.1 BUOYANT LINE AND POINT SOURCE DISPERSION MODEL (BLP).... A-3

A.2 CALINE 3..... A-7

A.3 CLIMATOLOGICAL DISPERSION MODEL (CDM 2.0)..... A-11

A.4 GAUSSIAN-PLUME MULTIPLE SOURCE AIR QUALITY ALGORITHM (RAM)..... A-15

A.5 INDUSTRIAL SOURCE COMPLEX MODEL (ISC)..... A-21

A.6 MULTIPLE POINT GAUSSIAN DISPERSION ALGORITHM WITH TERRAIN ADJUSTMENT (MPTER)..... A-25

A.7 SINGLE SOURCE (CRSTER) MODEL..... A-29

A.8 URBAN AIRSHED MODEL (UAM)..... A-33

A.9 OFFSHORE AND COASTAL DISPERSION MODEL (OCD)..... A-39

A.REF REFERENCES..... AR-1

A.4 GAUSSIAN-PLUME MULTIPLE SOURCE AIR QUALITY ALGORITHM (RAM)

References: Turner, D. B., and J. H. Novak, 1978. User's Guide for RAM. Publication No. EPA-600/8-78-016 Vols a, and b. U.S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS PB 294791 and PB 294792).

Reference: Catalano, J. A., D. B. Turner, and H. Novak, 1987. User's Guide for RAM--Second Edition. U.S. Environmental Protection Agency, Research Triangle Park, NC.
(Distributed as part of UNAMAP, Version 6, Documentation)

Availability: This model is available as part of UNAMAP (Version 6). The computer code is available on magnetic tape from:

Computer Products
National Technical Information Service
U. S. Department of Commerce
Springfield, Virginia 22161

Phone (703) 487-4650

Abstract: RAM is a steady-state Gaussian plume model for estimating concentrations of relatively stable pollutants, for averaging times from an hour to a day, from point and area sources in a rural or urban setting. Level terrain is assumed. Calculations are performed for each hour.

a. Recommendations for Regulatory Use

RAM is appropriate for the following applications:

point and area sources;

urban areas;

flat terrain;

transport distances less than 50 kilometers; and

one hour to one year averaging times.

The following options should be selected for regulatory applications:

Set the regulatory "default option" to automatically select stack tip downwash, final plume rise, buoyancy-induced dispersion (BID), a treatment for calms, the appropriate wind profile exponents, and the appropriate value for pollutant half-life.

b. Input Requirements

Source data: point sources require location, emission rate, physical stack height, stack gas exit velocity, stack inside diameter and stack gas temperature. Area sources require location, size, emission rate, and height of emissions.

Meteorological data: hourly surface weather data from the preprocessor program RAMMET which provides hourly stability class, wind direction, wind speed, temperature, and mixing height. Actual anemometer height (a single value) is also required.

Receptor data: coordinates of each receptor. Options for automatic placement of receptors near expected concentration maxima, and a gridded receptor array are included.

c. Output

Printed output optionally includes:

one to 24-hour and annual average concentrations at each receptor,

limited individual source contribution list, and

highest through fifth highest concentrations at each receptor for period, with the highest and high, second-high values flagged.

d. Type of Model

RAM is a Gaussian plume model.

e. Pollutant Types

RAM may be used to model primary pollutants. Settling and deposition are not treated.

f. Source-Receptor Relationship

RAM applies user-specified locations for all point sources and receptors.

Area sources are input as multiples of a user-defined unit area source grid size.

User specified stack heights are applied for individual point sources.

Up to 3 effective release heights may be specified for the area sources. Area source release heights are assumed to be appropriate for a 5 meter per second wind and to be inversely proportional to wind speed.

Actual separation between each source-receptor pair is used.

A.5 INDUSTRIAL SOURCE COMPLEX MODEL (ISC)

Reference: Environmental Protection Agency, 1986. Industrial Source Complex (ISC) Dispersion Model User's Guide, Second Edition, Volumes 1 and 2. Publication Nos. EPA-450/4-86-005a, and -005b. U. S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS PB86 234259 and PB86 234267).

Environmental Protection Agency, 1987. Industrial Source Complex (ISC) Dispersion Model. Addendum to the User's Guide. U. S. Environmental Protection Agency, Research Triangle Park, NC.

Availability: This model is available as part of UNAMAP (Version 6). The computer code is available on magnetic tape from:

Computer Products
National Technical Information Service
U.S. Department of Commerce
Springfield, Virginia 22161

Phone (703) 487-4650

Abstract: The ISC model is a steady-state Gaussian plume model which can be used to assess pollutant concentrations from a wide variety of sources associated with an industrial source complex. This model can account for the following: settling and dry deposition of particulates; downwash; area, line and volume sources; plume rise as a function of downwind distance; separation of point sources; and limited terrain adjustment. It operates in both long-term and short-term modes.

a. Recommendations for Regulatory Use

ISC is appropriate for the following applications:

industrial source complexes;

rural or urban areas;

flat or rolling terrain;

transport distances less than 50 kilometers; and

one hour to annual averaging times.

The following options should be selected for regulatory applications:

For short term modeling, set the regulatory "default option" (ISW(28)=1), which automatically selects stack tip downwash, final plume rise, buoyancy induced dispersion (BID), the vertical potential temperature gradient, a treatment for calms, the appropriate wind profile exponents, the appro-

priate value for pollutant half-life, and a revised building wake effects algorithm; set rural option (ISW(20)=0) or urban option (ISW(20)=3); and set the concentration option (ISW(1)=1).

For long term modeling, set the regulatory "default option" (ISW(22)=0), which automatically selects stack tip downwash, final plume rise, buoyancy-induced dispersion (BID), the vertical potential temperature gradient, the appropriate wind profile exponents, and the appropriate value for pollutant half-life, and a revised building wake effects algorithm; set rural option (ISW(9)=3) or urban option (ISW(9)=4); and set the concentration option (ISW(1)=1).

b. Input Requirements

Source data: location, emission rate, physical stack height, stack gas exit velocity, stack inside diameter, and stack gas temperature. Optional inputs include source elevation, building dimensions, particle size distribution with corresponding settling velocities, and surface reflection coefficients.

Meteorological data: ISCST requires hourly surface weather data from the preprocessor program RAMMET, which provides hourly stability class, wind direction, wind speed, temperature, and mixing height. For ISCLT, input includes stability wind rose (STAR deck), average afternoon mixing height, average morning mixing height, and average air temperature.

Receptor data: coordinates and optional ground elevation for each receptor.

c. Output

Printed output options include:

program control parameters, source data and receptor data;

tables of hourly meteorological data for each specified day;

"N"-day average concentration or total deposition calculated at each receptor for any desired combinations of sources;

concentration or deposition values calculated for any desired combinations of sources at all receptors for any specified day or time period within the day;

tables of highest and second-highest concentration or deposition values calculated at each receptor for each specified time period during an "N"-day period for any desired combinations of sources; and tables of the maximum 50 concentration or deposition values;

calculated for any desired combinations of sources for each specified time period.

d. Type of Model

ISC is a Gaussian plume model.

e. Pollutant Types

ISC may be used to model primary pollutants. Settling and deposition are treated.

f. Source-Receptor Relationships

ISC applies user-specified locations for point, line, area and volume sources, and user-specified receptor locations or receptor rings.

User input topographic elevation for each receptor is used. Elevations above stack top are reduced to the stack top elevation, i.e., "terrain chopping".

User input height above ground level may be used when necessary to simulate impact at elevated or "flag pole" receptors, e.g., on buildings.

Actual separation between each source-receptor pair is used.

g. Plume Behavior

ISC uses Briggs (1969, 1971, 1975) plume rise equations for final rise.

Stack tip downwash equation from Briggs (1974) is used.

Revised building wake effects algorithm is used. For stacks higher than building height plus one-half the lesser of the building height or building width, the building wake algorithm of Huber and Snyder (1976) is used. For lower stacks, the building wake algorithm of Schulman and Scire (Schulman and Hanna, 1986) is used, but stack tip downwash and BID are not used.

For rolling terrain (terrain not above stack height), plume centerline is horizontal at height of final rise above source.

Fumigation is not treated.

h. Horizontal Winds

Constant, uniform (steady-state) wind is assumed for each hour.

Straight line plume transport is assumed to all downwind distances.

Separate wind speed profile exponents (EPA, 1980) for both rural and urban cases are used.

An optional treatment for calm winds is included for short term modeling.

i. Vertical Wind Speed

Vertical wind speed is assumed equal to zero.

j. Horizontal Dispersion

Rural dispersion coefficients from Turner (1969) are used, with no adjustments for surface roughness or averaging time.

Urban dispersion coefficients from Briggs (Gifford, 1976) are used.

Buoyancy-induced dispersion (Pasquill, 1976) is included.

Six stability classes are used.

k. Vertical Dispersion

Rural dispersion coefficients from Turner (1969) are used, with no adjustments for surface roughness.

Urban dispersion coefficients from Briggs (Gifford, 1976) are used.

Buoyancy-induced dispersion (Pasquill, 1976) is included.

Six stability classes are used.

Mixing height is accounted for with multiple reflections until the vertical plume standard deviation equals 1.6 times the mixing height; uniform vertical mixing is assumed beyond that point.

Perfect reflection is assumed at the ground.

l. Chemical Transformation

Chemical transformations are treated using exponential decay. Time constant is input by the user.

m. Physical Removal

Settling and dry deposition of particulates are treated.

n. Evaluation Studies

Bowers, J. F., and A. J. Anderson, 1981. An Evaluation Study for the Industrial Source Complex (ISC) Dispersion Model, EPA Publication No. EPA-450/4-81-002. U. S. Environmental Protection Agency, Research Triangle Park, NC.

Bowers, J. F., A. J. Anderson, and W. R. Hargraves, 1982. Tests of the Industrial Source Complex (ISC) Dispersion Model at the Armco Middletown, Ohio Steel Mill, EPA Publication No. EPA-450/4-82-006. U. S. Environmental Protection Agency, Research Triangle Park, NC.

Scire, J. S., and L. L. Schulman, 1981. Evaluation of the BLP and ISC Models with SF6 Tracer Data and SO2 Measurements at Aluminum Reduction Plants. Air Pollution Control Association Specialty Conference on Dispersion Modeling for Complex Sources, St. Louis, MO.

Schulman, L. L., and S. R. Hanna, 1986. Evaluation of Downwash Modifications to the Industrial Source Complex Model. Journal of the Air Pollution Control Association, 36:258-264.

A.9 OFFSHORE AND COASTAL DISPERSION MODEL (OCD)

Reference: Hanna, S.R., L.L. Schulman, R.J. Paine and J.E. Pleim, 1984. The Offshore and Coastal Dispersion (OCD) Model User's Guide, Revised. OCS Study, MMS 84-0069. Environmental Research and Technology, Inc., Concord, MA. (NTIS PB 86-159803)

Availability: The above user's guide is available for $40.95 from NTIS. The computer tape is available from NTIS as number PB85-246106 at a cost of $800.

Technical Contact: Minerals Management Service, 12203 Sunrise Valley Drive, Mail Stop 644, Reston, VA 22091, ATTN: Mitchell Baer

Abstract: OCD is a straight-line Gaussian model developed to determine the impact of offshore emissions from point sources on the air quality of coastal regions. OCD incorporates overwater plume transport and dispersion as well as changes that occur as the plume crosses the shoreline. Hourly meteorological data are needed from both offshore and onshore locations. These include water surface temperature and overwater air temperature and relative humidity.

Some of the key features include platform building downwash, partial plume penetration into elevated inversions, direct use of turbulence intensities for plume dispersion, interaction with the overland internal boundary layer, and continuous shoreline fumigation.

a. Recommendations for Regulatory Use

OCD has been recommended for use by the Minerals Management Service for emissions located on the Outer Continental Shelf (Federal Register 50, 12248, 28 March 1985). OCD is applicable for overwater sources where onshore receptors are below the lowest source height. Where onshore receptors are above the lowest source height, offshore plume transport and dispersion may be modeled on a case-by-case basis in consultation with the EPA Regional Office.

b. Input Requirements

Source data: point source location, pollutant emission rate, building height, stack height, stack gas temperature, stack inside diameter, stack gas exit velocity, stack angle from vertical, elevation of stack base above water surface and gridded specification of the land/water surfaces. As an option, emission rate, stack gas exit velocity and temperature can be varied hourly.

Meteorological data (overwater): wind direction, wind speed, mixing height, relative humidity, air temperature, water surface temperature, vertical wind direction shear (optional), vertical temperature gradient (optional), turbulence intensities (optional). For all meteorological input variables, hourly data are preferred to climatological values.

Meteorological data (overland): wind direction, wind speed, temperature, stability class, mixing height.

Receptor data: location, height above local ground-level, ground-level elevation above the water surface.

c. Output

All input options, specification of sources, receptors and land/water map including locations of sources and receptors.

Summary tables of five highest concentrations at each receptor for each averaging period, and average concentration for entire run period at each receptor.

Optional case study printout with hourly plume and receptor characteristics.

Concentration files written to disk or tape can be used by ANALYSIS postprocessor to produce the highest concentrations for each receptor, the cumulative frequency distributions for each receptor, the tabulation of all concentrations exceeding a given threshold, and the manipulation of hourly concentration files.

d. Type of Model

OCD is a Gaussian plume model constructed on the framework of the MPTER model.

e. Pollutant Types

OCD may be used to model primary pollutants. Settling and deposition are not treated.

f. Source-Receptor Relationship

Up to 250 point sources and 180 receptors may be used.

Receptors and sources are allowed at any location.

The coastal configuration is determined by a grid of up to 3600 rectangles. Each element of the grid is designated as either land or water to identify the coastline.

g. Plume Behavior

As in MPTER, the basic plume rise algorithms are based on Briggs' recommendations.

Momentum rise includes consideration of the stack angle from the vertical.

The effect of drilling platforms, ships, or any overwater obstructions near the source are used to decrease plume rise following the approach of the BLP model.

Partial plume penetration of elevated inversions is included using the suggestions of Briggs (1975) and Weil and Brower (1984).

If overwater conditions are stable and overland conditions unstable, the Deardorff-Willis (1982) fumigation model is used to simulate the entrainment of the plume in the rising thermal internal boundary layer. The fumigation calculations are used only if the concentrations are lower than those resulting from the change to overland dispersion coefficients at the water/land interface.

h. Horizontal Winds

Constant, uniform wind is assumed for each hour.

Overwater wind speed can be estimated from overland wind speed using relationship of Hsu (1981).

Wind speed profiles are estimated using similarity theory (Businger 1973). Surface layer fluxes for these formulas are calculated from bulk aerodynamic methods.

i. Vertical Wind Speed

Vertical wind speed is assumed equal to zero.

j. Horizontal Dispersion

Lateral turbulence intensity is recommended as a direct estimate of horizontal dispersion. If lateral turbulence intensity is not available, it is estimated from boundary layer theory. For wind speeds less than 10 m/s, lateral turbulence intensity is assumed inversely proportional to wind speed.

Horizontal dispersion may be enhanced because of obstructions near the source. A virtual source technique, as in the BLP model, is used to simulate the initial plume dilution due to downwash.

Formulas recommended by Pasquill (1976) are used to calculate buoyant plume enhancement and wind direction shear enhancement.

At the water/land interface, the change to overland dispersion rates is modeled using a virtual source. The overland dispersion rates can be calculated from either lateral turbulence intensity or the Turner (1969) coefficients. The change is implemented where the plume intercepts the rising internal boundary layer.

k. Vertical Dispersion

Vertical turbulence intensity is recommended as a direct estimate of vertical dispersion. If not available, turbulence intensity is estimated from boundary layer theory. For very stable conditions, vertical dispersion is also a function of lapse rate.

Vertical dispersion may be enhanced because of obstructions near the source. A virtual source technique, as in the BLP model, is used to simulate the initial plume dilution due to downwash.

Formulas recommended by Pasquill (1976) are used to calculate buoyant plume enhancement.

At the water/land interface, the change to overland dispersion rates is modeled using a virtual source. The overland dispersion rates can be calculated from either vertical turbulence intensity or the Turner (1969) coefficients. The change is implemented where the plume intercepts the rising internal boundary layer.

l. Chemical Transformation

Chemical transformations are treated using exponential decay. Different rates can be specified by month and by day or night.

m. Physical Removal

Physical removal is also treated using exponential decay.

n. Evaluation Studies

Hanna, S.R., L.L. Schulman, R.J. Paine and J.E. Pleim, 1984. The Offshore and Coastal Dispersion (OCD) Model User's Guide, Revised. OCS Study, MMS 84-0069. Environmental Research & Technology, Inc., Concord, MA. (NTIS No. PB 86-159803)

Hanna, S.R., L.L. Schulman, R.J. Paine, J.E. Pleim and M. Baer, 1985. Development and Evaluation of the Offshore and Coastal Dispersion (OCD) Model. Journal of the Air Pollution Control Association, 35:1039-1047

A.REF REFERENCES

Benson, P. E., 1979. CALINE3 - A Versatile Dispersion Model for Predicting Air Pollution Levels Near Highways and Arterial Streets. Interim Report, Report Number FHWA/CA/TL-79/23. Federal Highway Administration, Washington, DC.

Briggs, G. A., 1969. Plume Rise. U. S. Atomic Energy Commission Critical Review Series, Oak Ridge National Laboratory, Oak Ridge, TN. NTIS TID-25075.

Briggs, G. A., 1971. Some Recent Analyses of Plume Rise Observations. Proceedings of the Second International Clean Air Congress, edited by H. M. Englund and W. T. Berry. Academic Press, New York, NY.

Briggs, G. A., 1974. Diffusion Estimation for Small Emissions. USAEC Report ATDL-106. U. S. Atomic Energy Commission, Oak Ridge, TN.

Briggs, G. A., 1975. Plume Rise Predictions. Lectures on Air Pollution and Environmental Impact Analyses. American Meteorological Society, Boston, MA, pp. 59-111.

Bjorklund, J. R., and J. F. Bowers, 1982. User's Instructions for the SHORTZ and LONGZ Computer Programs. EPA Publication No. EPA 903/9-82-004a,b. U. S. Environmental Protection Agency, Region III, Philadelphia, PA.

Businger, J. A., and S. P. Arya, 1974. Height of the Mixed Layer in the Stably Stratified Planetary Boundary Layer. Advances in Geophysics, Vol. 18A, F. N. Frankiel and R. E. Munn (Eds.), Academic Press, New York, NY.

Environmental Protection Agency, 1980. Recommendations on Modeling (October 1980 Meetings). Appendix G to: Summary of Comments and Responses on the October 1980 Proposed Revisions to the Guideline on Air Quality Models. Meteorology and Assessment Division, Office of Research and Development, Research Triangle Park, NC.

Gifford, F. A., Jr. 1976. Turbulent Diffusion Typing Schemes -- A Review. Nuclear Safety, 17:68-86.

Huber, A. H. and W. H. Snyder, 1976. Building Wake Effects on Short Stack Effluents. Third Symposium on Atmospheric Turbulence, Diffusion and Air Quality, American Meteorological Society, Boston, MA.

Irwin, J. S., 1979. A Theoretical Variation of the Wind Profile Power-Law Exponent as a Function of Surface Roughness and Stability. Atmospheric Environment, 13:191-194.

Lamb, R. G., et al., 1977. Continued Research in Mesoscale Air Pollution Simulation Modeling -- Vol. VI: Further Studies in the Modeling of Microscale Phenomena, Report Number EF77-143. Systems Applications, Inc., San Rafael, CA.

Larsen, R. I., 1971. A Mathematical Model for Relating Air Quality Measurements to Air Quality Standards. Office of Air Programs Publication No. AP-89. U. S. Environmental Protection Agency, Research Triangle Park, NC.

Liu, M. K., et al., 1976. The Chemistry, Dispersion, and Transport of Air Pollutants Emitted from Fossil Fuel Power Plants in California: Data Analysis and Emission Impact Model. Systems Applications, Inc., San Rafael, CA.

McElroy, J. L. and F. Pooler, Jr., 1968. St. Louis Dispersion Study Volume II-Analysis. NAPCA Publication No. AP-53. U. S. Environmental Protection Agency, Research Triangle Park, NC.

Moore, G. E., T. E. Stoeckenius and D. A. Stewart, 1982. A Survey of Statistical Measures of Model Performance and Accuracy for Several Air Quality Model. EPA Publication No. EPA 450/4-83-001. U. S. Environmental Protection Agency, Research Triangle Park, NC.

Pasquill, F., 1976. Atmospheric Dispersion Parameters in Gaussian Plume Modeling Part II. Possible Requirements for Change in the Turner Workbook Values. EPA Publication No. EPA 600/4-76-030b. U. S. Environmental Protection Agency, Research Triangle Park, NC.

Turner, D. B., 1969. Workbook of Atmospheric Dispersion Estimates. PHS Publication No. 999-26. U. S. Environmental Protection Agency, Research Triangle, Park, NC.

Whitten, G. Z., J. P. Killus, and H. Hogo, 1980. Modeling of Simulated Photochemical Smog with Kinetic Mechanisms. Volume 1. Final Report. EPA Publication No. EPA 600/3-80-028a. U. S. Environmental Protection Agency, Research Triangle Park, NC.

Briggs, G. A., 1975. Plume Rise Predictions. Lectures on Air Pollution and Environmental Impact Analyses. American Meteorological Society, Boston, MA, pp. 59-111.

Businger, J. A., 1973. Turbulence Transfer in the Atmospheric Surface Layer. Workshop in Micrometeorology. American Meteorological Society, Boston, MA, pp. 67-100.

Deardorff, J. W. and G. E. Willis, 1982. Ground Level Concentrations Due to Fumigation into an Entraining Mixing Layer. Atmospheric Environment, 16:1159-1170.

Hsu, S. A., 1981. Models for Estimating Offshore Winds from Onshore Meteorological Measurements. Boundary Layer Meteorology, 20:341-352.

Schulman, L. L., S. R. Hanna, and D. W. Heinold, 1985. Evaluation of Proposed Downwash Modifications to the Industrial Source Complex Model. ERT Document P-B810-012. Prepared for American Petroleum Institute.

Weil, J. C., and R. P. Brower, 1984. An Updated Gaussian Plume Model for Tall Stacks. Journal of the Air Pollution Control Association, 34:818-827.

APPENDIX B

TABLE OF CONTENTS

B.0	INTRODUCTION	B-1
B.1	AIR QUALITY DISPLAY MODEL (AQDM)	B-3
B.2	AIR RESOURCES REGIONAL POLLUTION ASSESSMENT (ARRPA) MODEL	B-7
B.3	APRAC-3	B-11
B.4	COMPTER	B-15
B.5	ERT AIR QUALITY MODEL (ERTAQ)	B-19
B.6	ERT VISIBILITY MODEL	B-23
B.7	HIWAY-2	B-27
B.8	INTEGRATED MODEL FOR PLUMES AND ATMOSPHERIC CHEMISTRY IN COMPLEX TERRAIN (IMPACT)	B-31
B.9	LONGZ	B-35
B.10	MARYLAND POWER PLANT SITING PROGRAM (PPSP) MODEL	B-39
B.11	MESOSCALE PUFF MODEL (MESOPUFF II)	B-43
B.12	MESOSCALE TRANSPORT DIFFUSION AND DEPOSITION MODEL FOR INDUSTRIAL SOURCES (MTDDIS)	B-47
B.13	MODELS 3141 and 4141	B-51
B.14	MULTIMAX	B-55
B.15	MULTIPLE POINT SOURCE DIFFUSION MODEL (MPSDM)	B-59
B.16	MULTI-SOURCE (SCSTER) MODEL	B-63
B.17	PACIFIC GAS AND ELECTRIC PLUME5 MODEL	B-67
B.18	PLMSTAR AIR QUALITY SIMULATION MODEL	B-71
B.19	PLUME VISIBILITY MODEL (PLUVUE II)	B-75
B.20	POINT, AREA, LINE SOURCE ALGORITHM (PAL)	B-79
B.21	RANDOM WALK ADVECTION AND DISPERSION MODEL (RADM)	B-83
B.22	REACTIVE PLUME MODEL (RPM-II)	B-87

B.23 REGIONAL TRANSPORT MODEL (RTM-II) B-91

B.24 SHORTZ B-95

B.25 SIMPLE LINE-SOURCE MODEL (GMLINE)..... B-99

B.26 TEXAS CLIMATOLOGICAL MODEL (TCM) B-103

B.27 TEXAS EPISODIC MODEL (TEM) B-107

B.28 AVACTA II MODEL B-111

B.REF REFERENCES BR-1

B.29 AVACTA II

Reference: Zannetti, P., G. Carboni and R. Lewis, 1985. AVACTA II User's Guide (Release 3). AeroVironment, Inc., Technical Report AV-OM-85/520.

Availability: A magnetic tape copy of the FORTRAN coding and the user's guide are available at a cost of $2,500 (non-profit organization) or $3,500 (other organizations) from:

AeroVironment, Inc.
825 Myrtle Avenue
Monrovia, CA 91016

Phone (818) 357-9983

Abstract: The AVACTA II model is a Gaussian model in which atmospheric dispersion phenomena are described by the evolution of plume elements, either segments or puffs. The model can be applied for short time (e.g., one day) simulations in both transport and calm conditions.

The user is given flexibility in defining the computational domain, the three-dimensional meteorological and emission input, the receptor locations, the plume rise formulas, the sigma formulas, etc. Without explicit user's specifications, standard default values are assumed.

AVACTA II provides both concentration fields on the user specified receptor points, and dry/wet deposition patterns throughout the domain. The model is particularly oriented to the simulation of the dynamics and transformation of sulfur species (SO_2 and $SO_4^=$), but can handle virtually any pair of primary-secondary pollutants.

a. Recommendations for Regulatory Use

AVACTA II can be used if it can be demonstrated to estimate concentrations equivalent to those provided by the preferred model for a given application. AVACTA II must be executed in the equivalent mode.

AVACTA II can be used on a case-by-case basis in lieu of a preferred model if it can be demonstrated, using the criteria in Section 3.2, that AVACTA II is more appropriate for the specific application. In this case the model options/modes which are most appropriate for the application should be used.

b. Input Requirements (all time-varying)

A time-varying input is required at each computational step. Only those data which have changed need to be input by the user.

Source data requirements are: Coordinates, emission rates of primary and secondary pollutants, initial plume sigmas (for non-point sources), exit temperature, exit velocity, stack inside diameter.

Meteorological data requirements are: surface wind measurements, wind profiles (if available), atmospheric stability profiles, mixing heights.

Receptor data requirements are: receptor coordinates.

Other data requirements: coordinates of the computational domain, grid cell specification, terrain elevations, user's computational and printing options.

c. Output

The model's output is provided according to user's printing flags. Hourly, 3-hour and 24-hour concentration averages are computed, together with highest and highest-second-highest concentration values. Both partial and total concentrations are provided.

d. Type of Model

AVACTA II is Gaussian plume segment/puff model.

e. Pollutant Types

AVACTA II can handle any couple of primary-secondary pollutants (e.g. SO_2 and $SO_4^=$).

f. Source Receptor Relationship

The AVACTA II approach maintains the basic Gaussian formulation, but allows a numerical simulation of both nonstationary and nonhomogeneous meteorological conditions. The emitted pollutant material is divided into a sequence of "elements," either segments or puffs, which are connected together but whose dynamics are a function of the local meteorological conditions. Since the meteorological parameters vary with time and space, each element evolves according to the different meteorological conditions encountered along its trajectory.

AVACTA II calculates the partial contribution of each source in each receptor during each interval. The partial concentration is the sum of the contribution of all existing puffs, plus that of the closest segment.

g. Plume Behavior

The user can select the following plume rise formulas:

Briggs (1969, 1971, 1972)
CONCAWE (Briggs, 1975)
Lucas-Moore (Briggs, 1975)
User's function, i.e., a subroutine supplied by the user

With cold plumes, the program uses a special routine for the computation of the jet plume rise. The user can also select several computational options that control plume behavior in complex terrain and its total/partial reflections.

h. Horizontal Winds

A 3D mass-consistent wind field is optionally generated.

i. Vertical Wind Speed

A 3D mass-consistent wind field is optionally generated.

j. Horizontal Dispersion

During each step, the sigmas of each element are increased. The user can select the following sigma functions:

Pasquill-Gifford-Turner (in the functional form specified by Green et al., 1980)
Brookhaven (Gifford, 1975)
Briggs, open country (Gifford, 1975)
Briggs, urban, i.e., McElory-Pooler, (Gifford, 1975)
Irwin (1979)
LO-LOCAT (MacCready et al., 1974)
User-specified function, by points
User-specified function, with a user's subroutine

The virtual distance/age concept is used for incrementing the sigmas at each time step.

k. Vertical Dispersion

During each step, the sigmas of each element are increased. The user can select the following sigma functions:

Pasquill-Gifford-Turner (in the functional form specified by Green et al., 1980)
Brookhaven (Gifford, 1975)
Briggs, open country (Gifford, 1975)
Briggs, urban, i.e., McElroy-Pooler, (Gifford, 1975)
LO-LOCAT (MacCready et al., 1974)
User-specified function, with a user's subroutine

The virtual distance/age concept is used for incrementing the sigmas at each time step.

l. Chemical Transformation

First order chemical reactions (primary-to-secondary pollutant)

m. Physical Removal

First order dry and wet deposition schemes

n. Evaluation Studies

Zannetti P., G. Carboni and A. Ceriani, 1985. AVACTA II Model Simulations of Worst-Case Air Pollution Scenarios in Northern Italy. 15th International Technical Meeting on Air Pollution Modeling and Its Application, St. Louis, Missouri, April 15-19.

McElroy, J. L. and F. Pooler, 1968. St. Louis Dispersion Study, Volume II-Analyses. NAPCA Publication No. AP-53. National Air Pollution Control Administration, Arlington, VA.

Mitchell, Jr., A. E. and K. O. Timbre, 1979. Atmospheric Stability Class from Horizontal Wind Fluctuation. Presented at the 72nd Annual Meeting of the Air Pollution Control Association, Cincinnati, OH.

Moore, G. E., T. E. Stoeckenius and D. A. Stewart, 1982. A Survey of Statistical Measures of Model Performance and Accuracy for Several Air Quality Models. EPA Publication No. EPA 450/4-83-001. U. S. Environmental Protection Agency, Research Triangle Park, NC.

Mueller, S. F. and R. J. Valente, 1983. Meteorological Data Preprocessing Manual for the Air Resources Regional Pollution Assessment Model (Generic Version). TVA/ONR/AQB-83/13. Tennessee Valley Authority, Muscle Shoals, Al.

Mueller, S. F., R. J. Valente, T. L. Crawford, A. L. Sparks, and L. L. Gautney, Jr., 1983. Description of the Air Resources Regional Pollution Assessment (ARRPA) Model: September 1983. TVA/ONR/AQB-83/14. Tennessee Valley Authority, Muscle Shoals, AL.

Myers, T. C., and J. E. Langstaff, 1981. Application of Meteorological and Air Quality Modeling to the Las Vegas and Tampa Bay Areas. SAI Number 101-81EF81-108. Systems Applications, Inc., San Rafael, CA.

Pasquill, F., 1976. Atmospheric Dispersion Parameters in Gaussian Plume Modeling, Part II. EPA 600/4-76-030b. U. S. Environmental Protection Agency, Research Triangle Park, NC.

Seigneur, C., T. W. Tesche, P. M. Roth and M. K. Liu, 1983. On the Treatment of Point Source Emissions in Urban Air Quality Modeling. Atmospheric Environment, 17:1655-1676.

Schere, K. L., and K. L. Demerjian, 1977. Calculation of Selected Photolytic Rate Constants over a Diurnal Range. EPA-600/477-015. U. S. Environmental Protection Agency, Research Triangle Park, NC.

Turner, D. B., 1964. A Diffusion Model of An Urban Area. Journal of Applied Meteorology, 3:83-91.

Turner, D. B., 1969. Workbook of Atmospheric Dispersion Estimates. PHS Publication No. 999-AP-26. U. S. Environmental Protection Agency, Research Triangle Park, NC.

Venkatram, A., 1980. Dispersion From an Elevated Source in a Corrective Boundary Layer. Atmospheric Environment, 14:1-10.

Wesely, M. L., and B. B. Hicks, 1977. Some Factors That Affect the Deposition Rates of Sulfur Dioxide and Similar Gases on Vegetation. Journal of the Air Pollution Control Association, 27:1110-1116.

Whitten, G. Z., J. P. Killus, and H. Hogo, 1980. Modeling of Simulated Photochemical Smog with Kinetic Mechanisms. Volume 1. Final Report. EPA Publication No. EPA 600/3-80-028a. U. S. Environmental Protection Agency, Research Triangle Park, NC.

Green, A. E., Singhal R. P., and R. Venkateswar, 1980. Analytical Extensions of the Gaussian Plume Model. Journal of the Air Pollution Control Association, 30:773-776.

MacCready, P. B., Baboolal, L. B., and P. B. Lissaman, 1974. Diffusion and Turbulence Aloft Over Complex Terrain. Preprint Volume, AMS Symposium on Atmospheric Diffusion and Air Pollution, Santa Barbara, CA. American Meteorological Society, Boston, MA.